THÜNEN

Biophysical controls on evapotranspiration and water use efficiency in natural, semi-natural and managed African ecosystems

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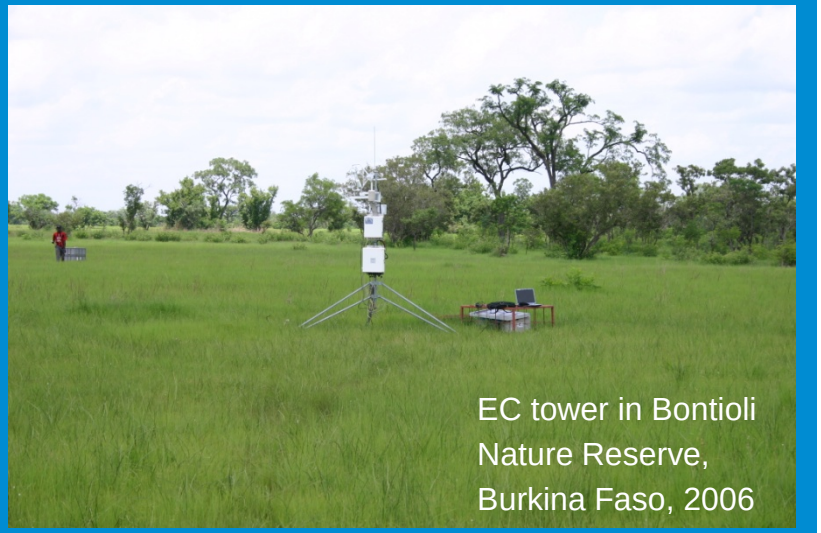
Outline:

- Eddy tower locations
- *E* vs. *P*
- Lags between *E* and R_n (*E* and *D*)
- Stomatal vs. available energy control
  $\rightarrow$ Priestley-Taylor α and g_c
- Water use efficiency



EC tower in Bontioli Nature Reserve, Burkina Faso, 2006

Thünen Institute (TI-AK)
Braunschweig, Germany

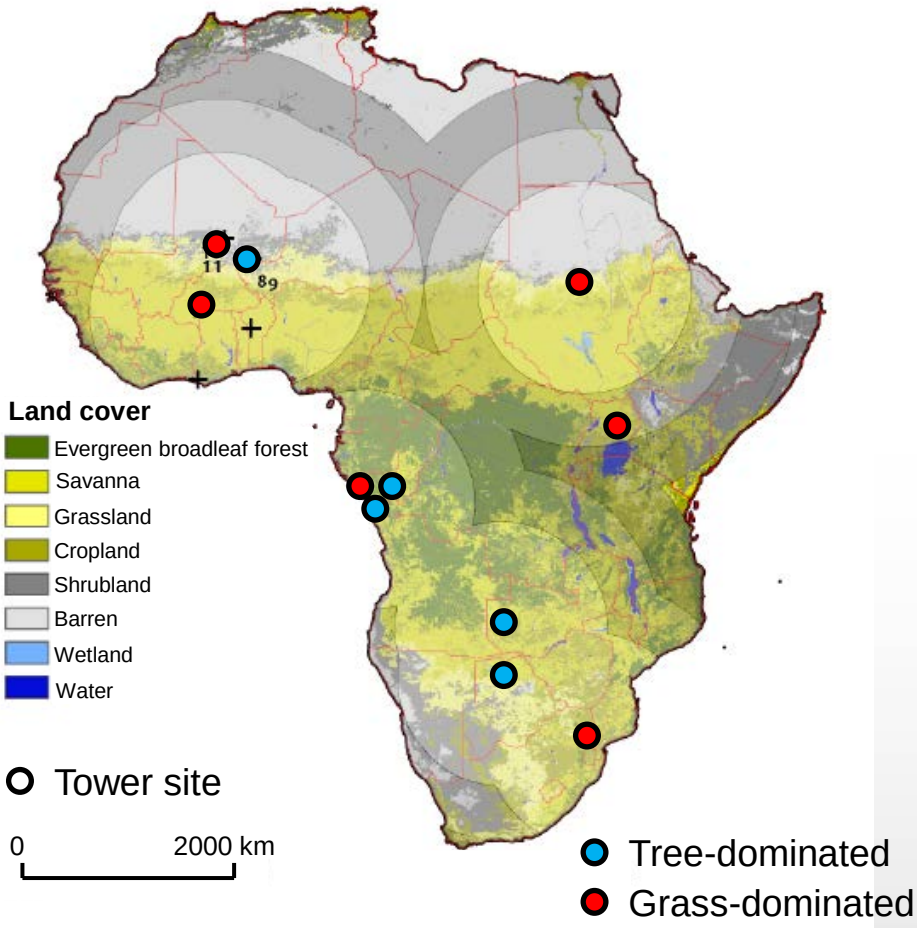
EGU General Assembly
Vienna, Austria, 2013

Site locations

11 sites:

- Burkina Faso
- Botswana
- Republic of Congo (3x)
- Mali (2x)
- South Africa
- Sudan
- Uganda
- Zambia

→ In total 21 site years of EC data



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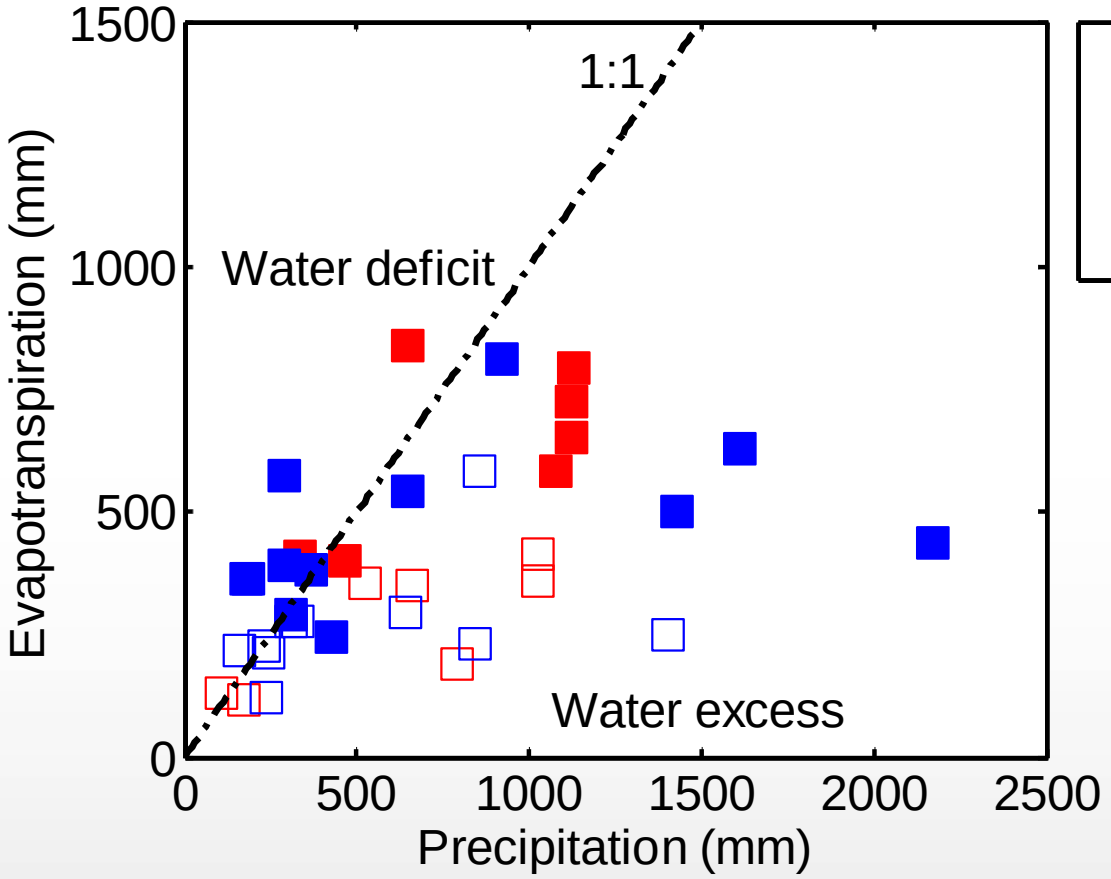
E vs. *P* – Annual and wet season



- Annual - C4 dominated
- Annual - C3 dominated
- Wet season - C4 dominated
- Wet season - C3 dominated

→ *E* plateaus with increasing *P*

→ *E* exceeds both annual and wet season *P* at some sites with low *P*

→ No significant differences between C3 and C4 sites

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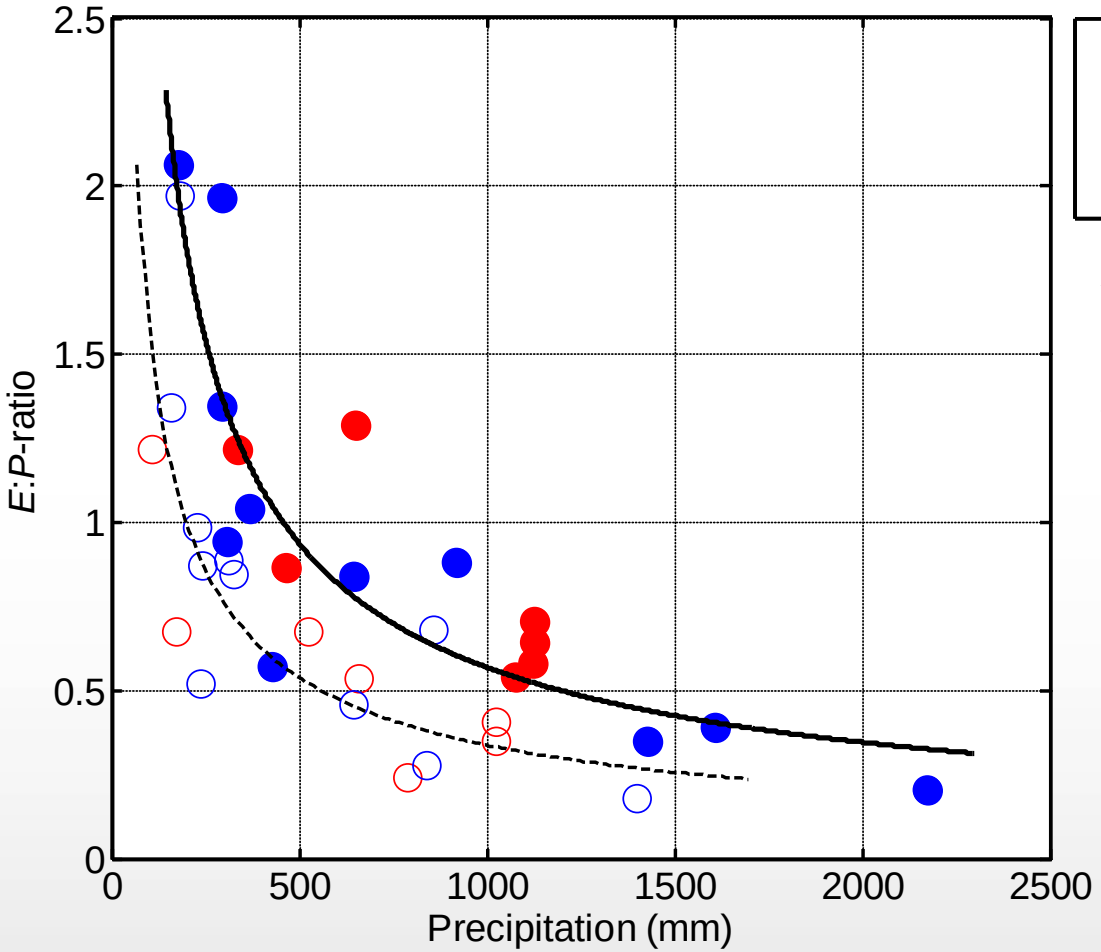
EGU General Assembly, Vienna, Austria

E:*P*-ratio vs. *P*



- Annual - C4 dominated
- Annual - C3 dominated
- Wet season - C4 dominated
- Wet season - C3 dominated

Annual fit: $R^2 = 0.75$
$E = 81.76P^{-0.72}$

Wet season fit: $R^2 = 0.69$
$E = 35.50P^{-0.67}$

→ Only dry sites exhibit *E*:*P*-ratios >1

→ Limitation on *E* at wet sites

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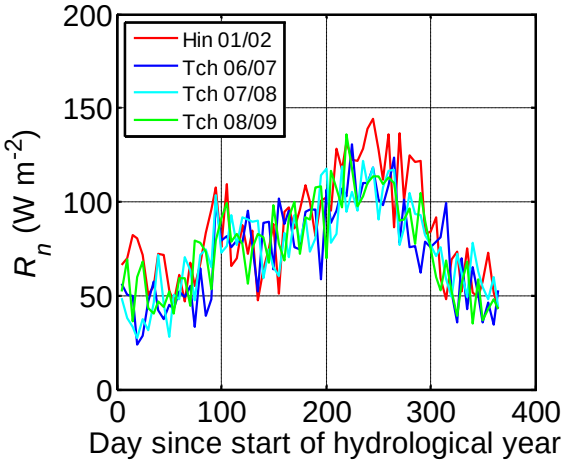
Climatic drivers:
Time lags between E and R_n (seasonal)

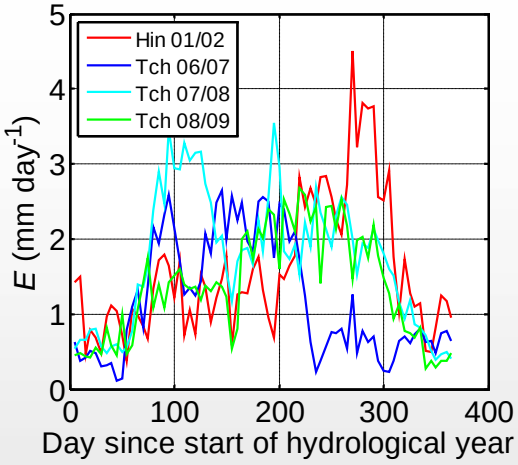
Only equatorial sites were chosen

→ Both linear and hysteretic relationships → R_n lagging behind E

→ C_3 sites seemed to be more coupled

→ R_n likely no significant driving force on seasonal basis





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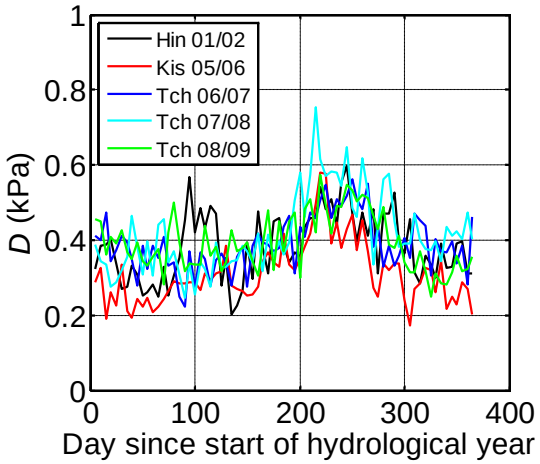
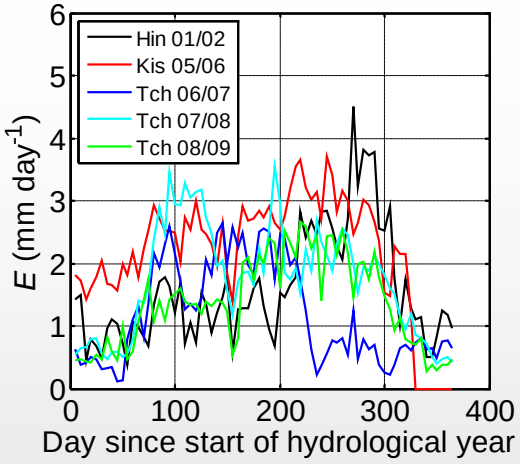
Climatic drivers:
Time lags between *E* and *D* (seasonal)

→ Same pattern found for the seasonal lag between *E* and *D*



→ Declining *E* while *D* rises suggests other controlling mechanisms (e.g., stomata) at C_4 sites



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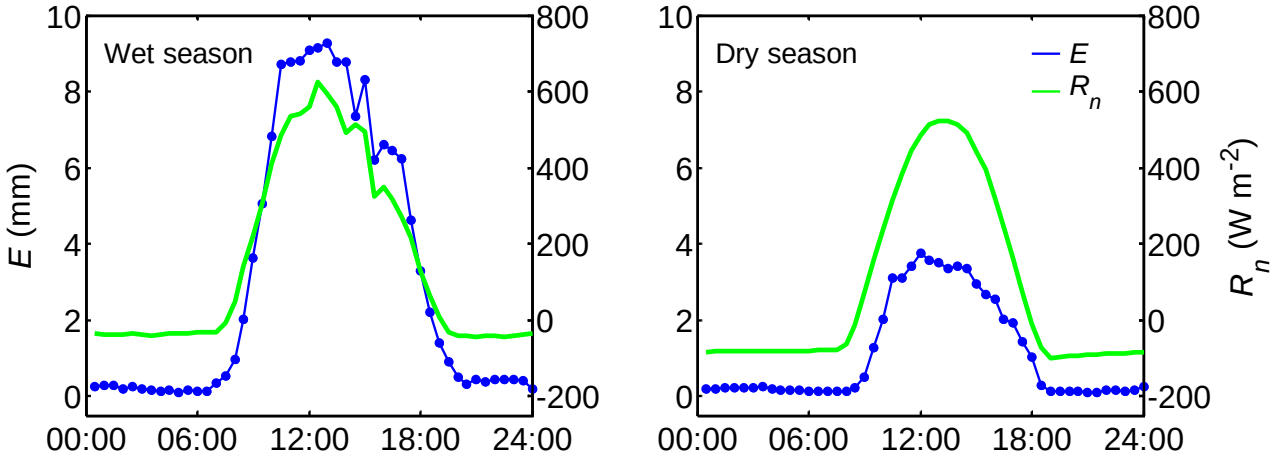
Climatic drivers:
Time lags between *E* and R_n; *E* and *D* (diurnal)

Example site:

Zambia, Mongu (C_3)



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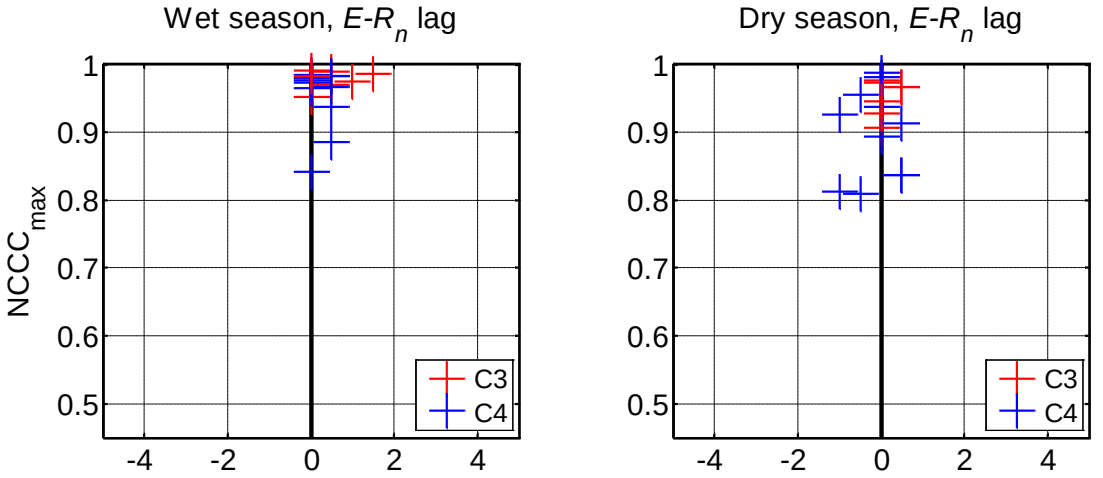
Climatic drivers:
Time lags between *E* and R_n; *E* and *D* (diurnal)

→ Close coupling bewteen *E* and R_n

→ Positive lag numbers in WS ⇒ available energy control on *E*

→ Decoupling bewteen *E* and *D*

→ Negative lag numbers ⇒ at least to some extent stomatal control on *E*



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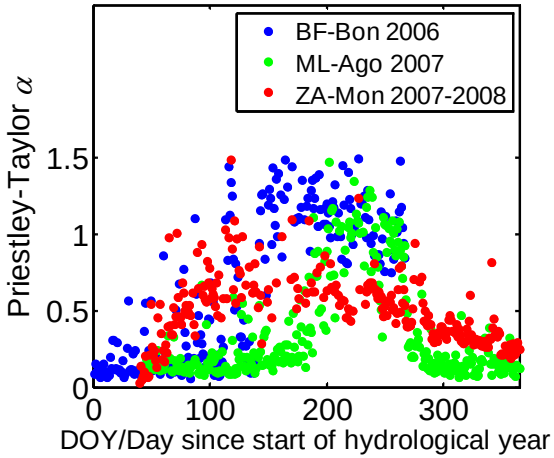
Priestley-Taylor α and canopy conductance (g_c)

→ Seasonal course of α was closely linked to rainfall pattern

→ Stomatal control at Zambian site (C_3)

→ No significant stomatal control at C_4 sites (seasonal); water limitation during dry season keeps α values <1.26



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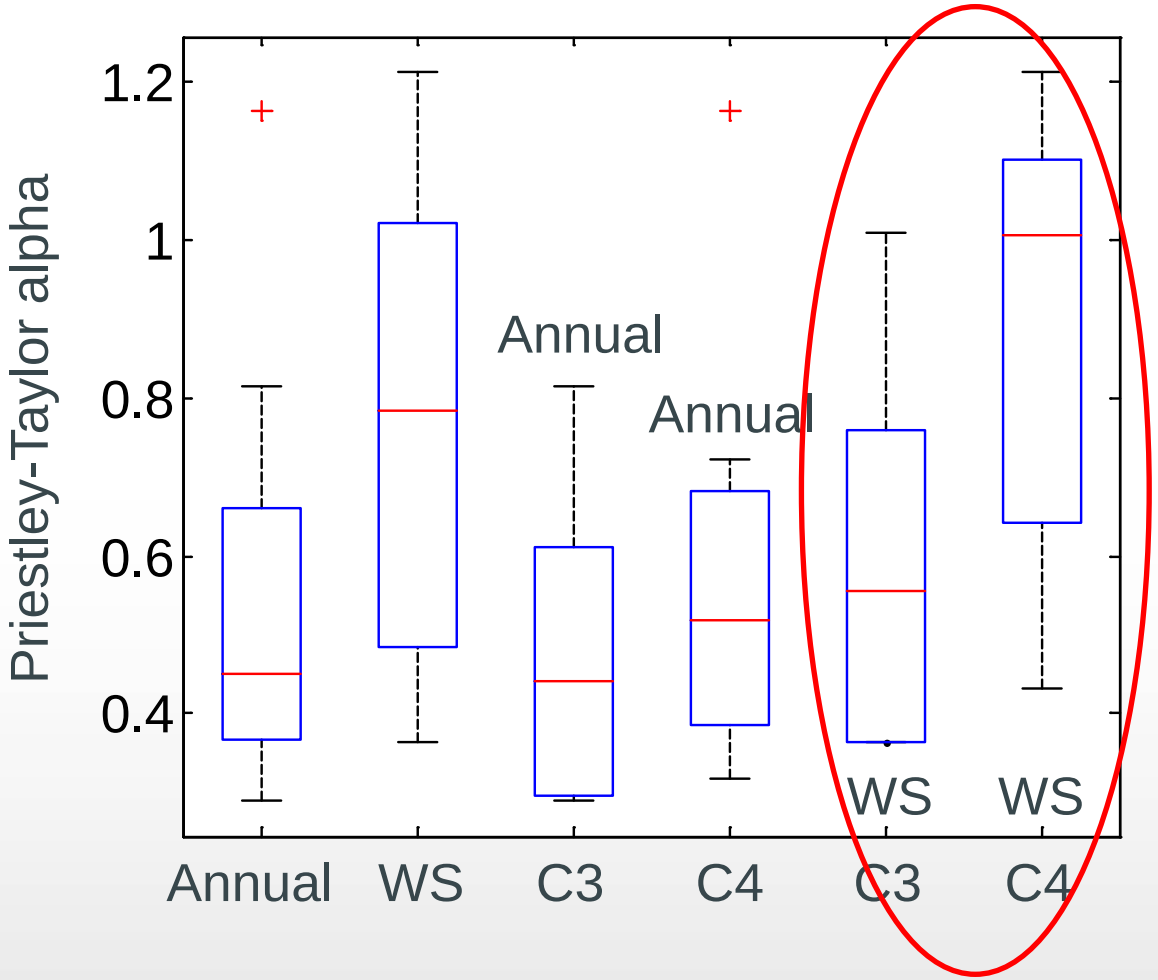
Priestley-Taylor α – Seasonal and system differences

→ Higher evaporation ratio
at grass-dominated sites
AND/OR stomatal control
on *E* at tree-dominated sites



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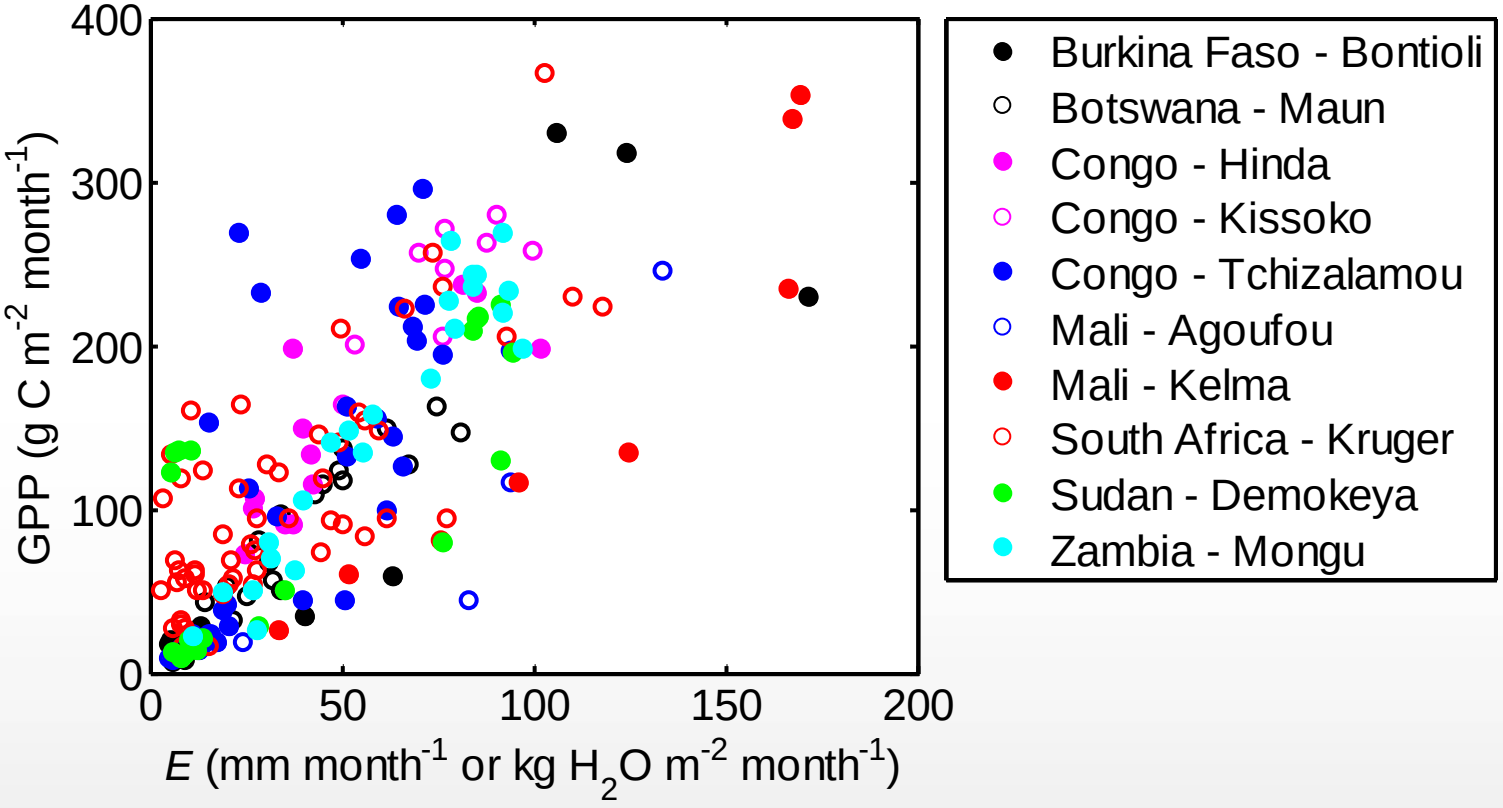
Water use efficiency



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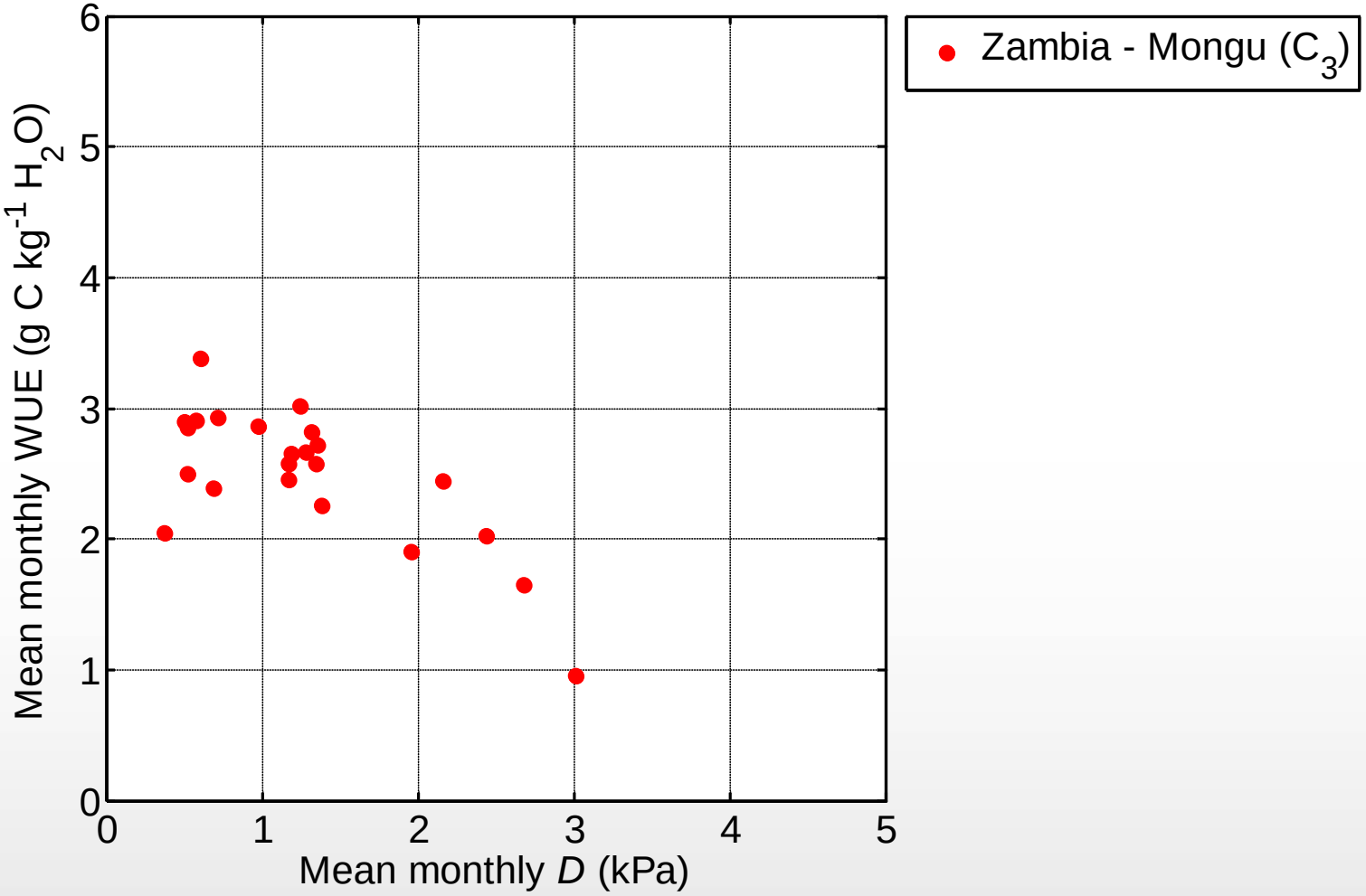
Dependency of monthly WUE on *D*



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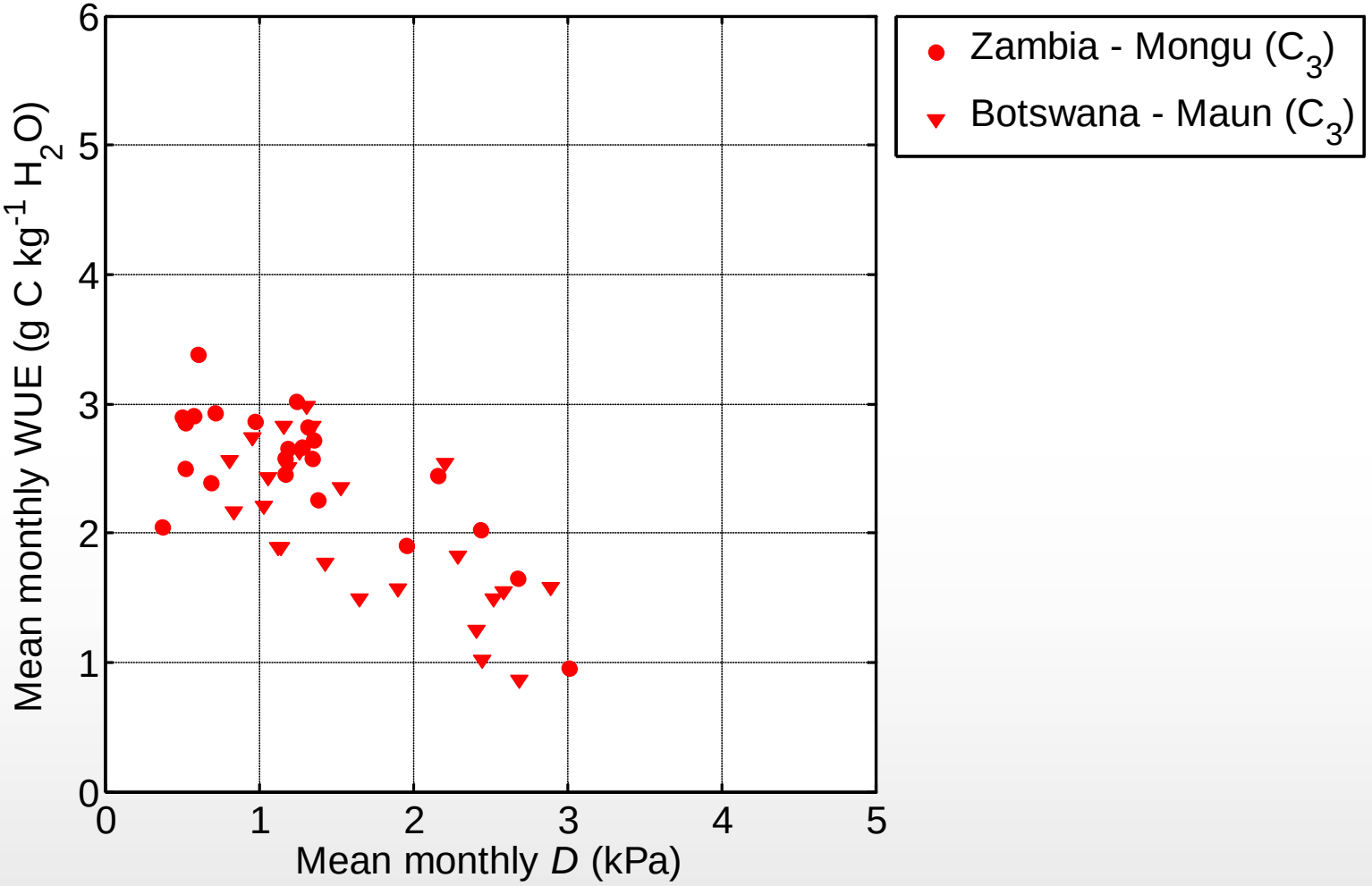
Dependency of monthly WUE on *D*



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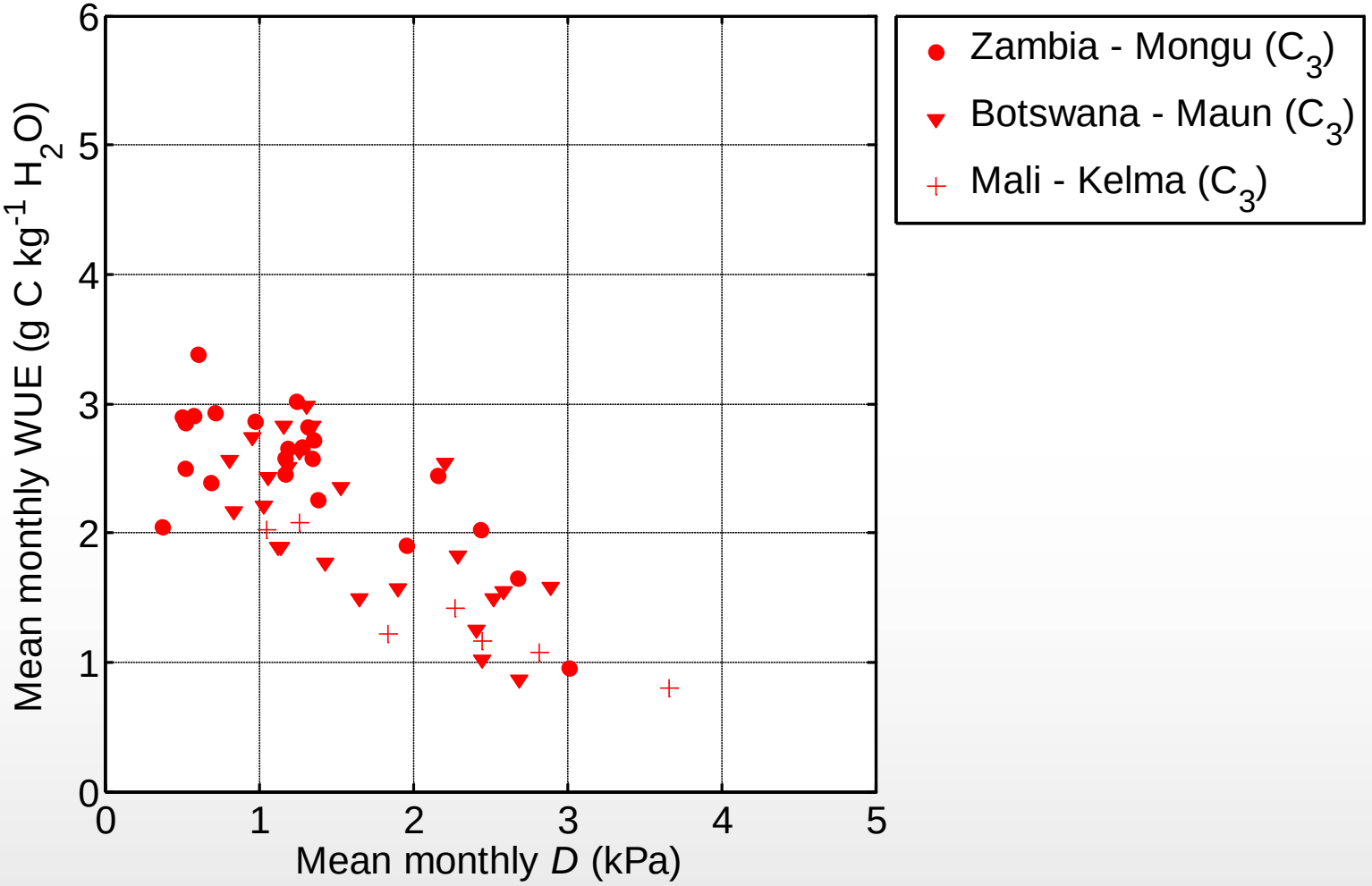
Dependency of monthly WUE on *D*



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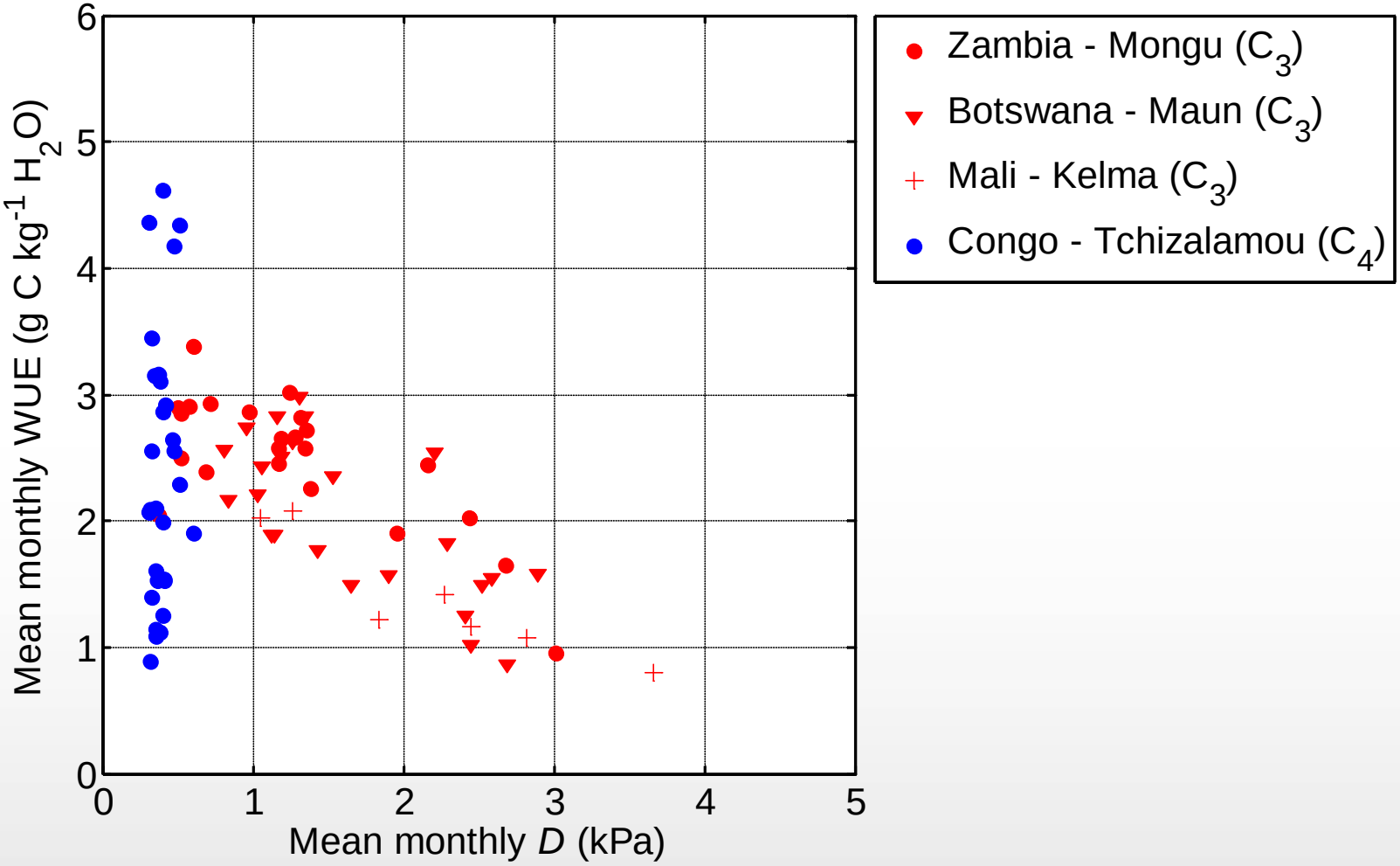
Dependency of monthly WUE on *D*



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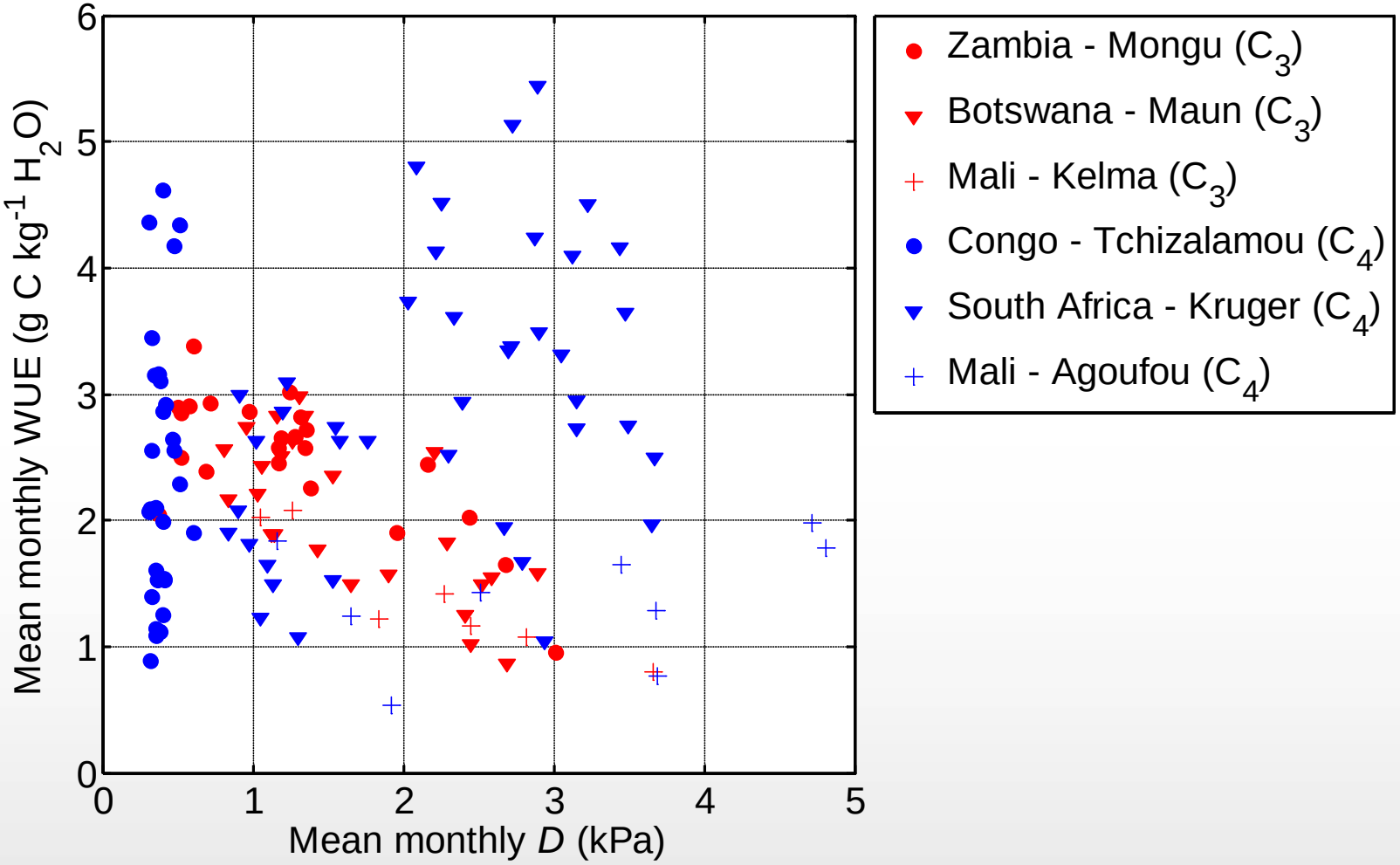
Dependency of monthly WUE on *D*



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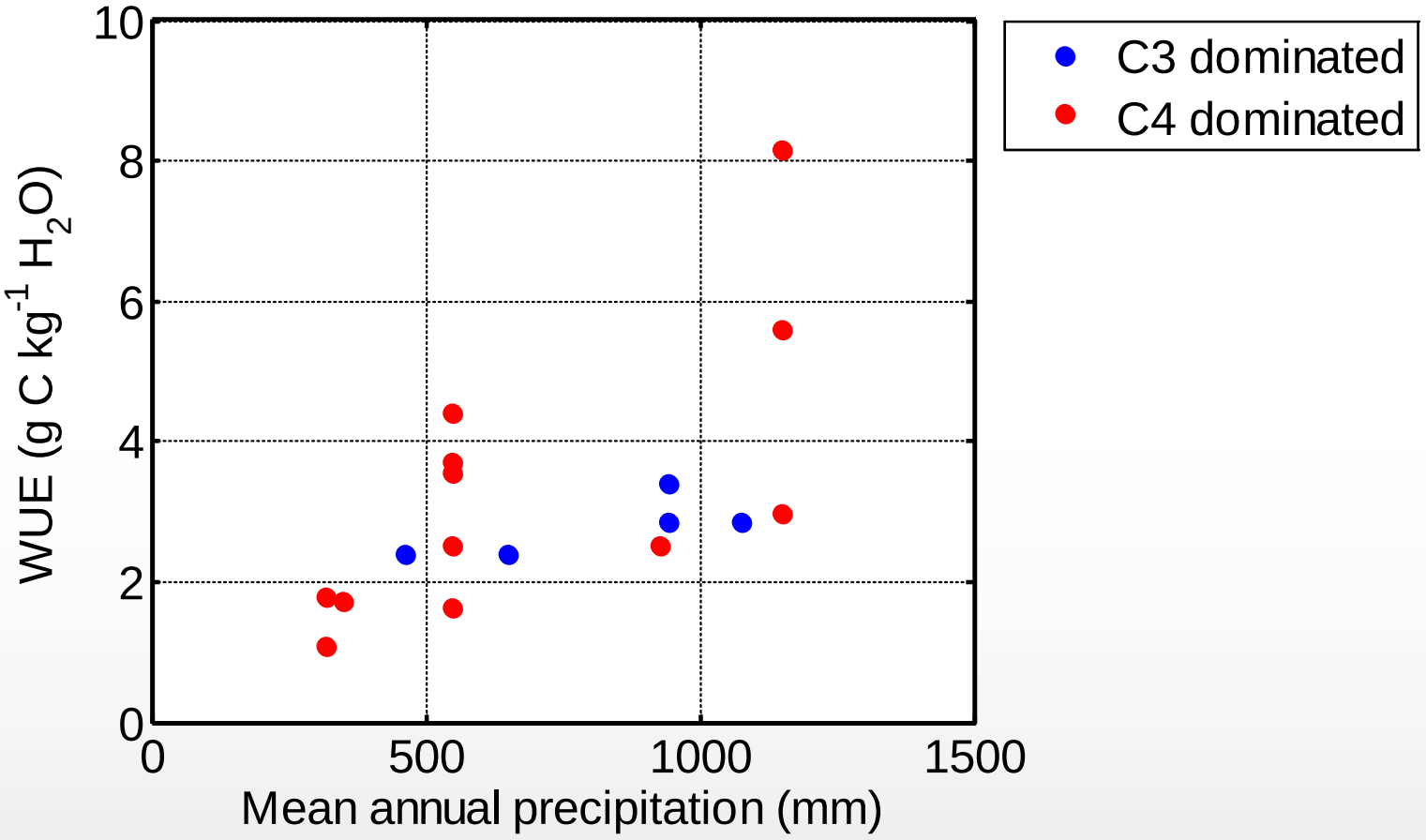
Water use efficiency in relation to MAP



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Conclusions

→ *E* plateaus with increasing *P;* seasonal course of *E* mainly driven by water availability

→ *E* at C_3 sites were more closely coupled (to R_n and *D*) than at C_4 sites

→ Non-equatorial C_4 sites reach α values of 1.26 in WS

→ Variable WUE (1.5 to 4) among sites; C_3 sites clearly dependent on *D*; constant WUE during WS positively correlated to MAP

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Acknowledgements

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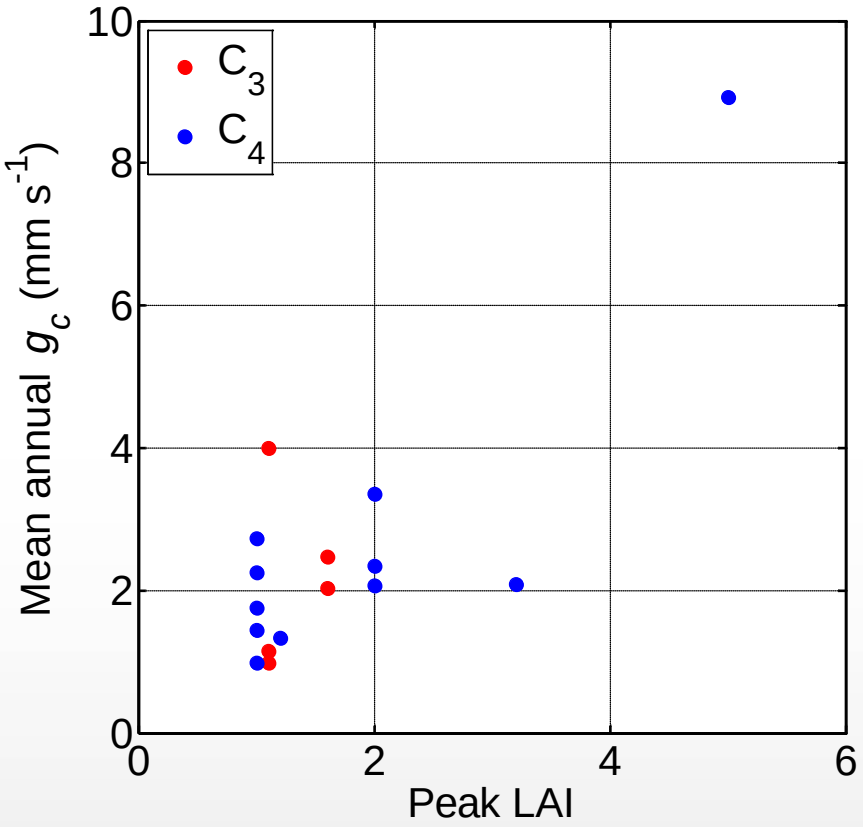
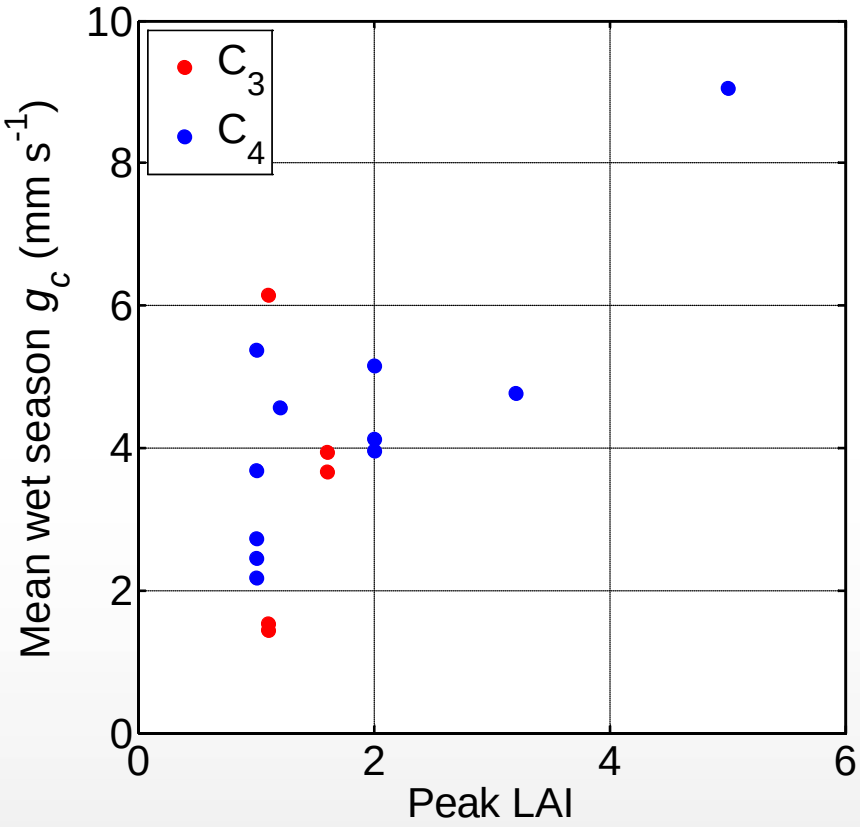
g_c vs. LAI





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